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The Foliar Micro-morphology of *Solanum aculeastrum*, a Medicinal Plant of South Africa

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Abstract: *Solanum aculeastrum* is an important medicinal plant which is used for the treatment of several diseases including cancer in South Africa. The structure and distribution of foliar appendages on the leaves of this plant were examined by scanning electron microscope. Both glandular and non-glandular trichomes were observed, which differed from each other in morphology and location on the leaf. While short-stalked (SST) glandular trichomes were abundant on the adaxial leaf surface, single, multicellular and pointed stellate trichomes (ST) having 13-15 arms, were abundant on the abaxial surface of the leaf, together with long-stalked glandular trichomes (LST). We hypothesize that the bioactive therapeutic compounds secreted by *S. aculeastrum* are produced in these glandular trichomes.

Key words: *Solanum aculeastrum*, stellate trichomes, glandular hair

INTRODUCTION

Solanum aculeastrum (subsp. *aculeastrum*) Dunal, occurs from tropical Africa down to South Africa. It is a multi-branched shrub, 1-5 m high, heavily armed with large prickles and is wide-spread in South Africa. In southern Africa, it grows in areas with high rainfall of more than 700 mm per year and at altitudes from 275 to 1,780 m (Koduru *et al*., 2006). It has been recorded from gentle to steep slopes, on various soil types such as sandy soils, reddish brown clay-loam and brown sandy loam. *S. aculeastrum* has high medicinal value. Its berries and leaves are sometimes used as soap substitute; apparently because of its high saponin content. Local healers use the extremely bitter berries and leaves for the treatment of various diseases in humans and domestic animals. Both mature and immature berries contain the poisonous alkaloid, α-solanine (Hutchings *et al*., 1996). Other bioactive compounds that have been isolated from this plant include solaculine A (Wanyonyi *et al*., 2002) from the root bark and solamargine, beta-solamarine, solasonine and solasodine from the fruits (Watt and Breyer-Brandwijk, 1962; Drewes and Van Staden, 1995; Wanyonyi *et al*., 2002). The fresh and boiled ripe berries and leaves are used as a cure for jigger wounds and gonorrhoea, respectively (Agnew and Agnew, 1994). Moderate antioxidant activity of *Solanum aculeastrum* using crude extracts of berries have been previously reported (Koduru *et al*., 2006). Recent discussion with traditional healers of the Eastern Cape Province in South Africa revealed that the plant is used for the treatment of cancer, particularly breast cancer (Koduru *et al*., 2006).

Trichomes are commonly found on the surfaces of leaves and some other plant organs. Scientific interest in plant trichomes is based on their functional importance and on the economic usefulness of some trichome-produced products (Valkama *et al*., 2003). Histochemical studies indicated that the secretions from most trichomes contain terpernoids (essential oils) and flavonoid aglycones (Afolayan and Meyer, 1995; Ascensao *et al*., 1999). Terpenes are reported to have anti-tumour activity (Aquino *et al*., 1990; Patocka, 2003). The Solanaceae family includes a large number of species which are rich in alkaloids of medicinal value; some of these plants have great economic importance (Maiti *et al*., 2002). Trichome-produced compounds which showed anti-tumour activity have been isolated from some members of Solanaceae (Guo and Wagner, 1995).

No information is available on the morphology and ultrastructure of the leaf appendages of *S. aculeastrum*. We hypothesize that the bioactive therapeutic compounds of this plant are produced in the leaf trichomes. The objective of this study therefore was to investigate the structure and distribution of different trichome types observed on the leaves of *S. aculeastrum*, which could be the site of production of reported compounds that have been found to be biologically active.

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MATERIALS AND METHODS

Plant material: The leaves of *S. aculeastrum* were collected from plants naturally occurring in the wild at Kayalethu village in the Eastern Cape Province of South Africa (latitudes 30°00'- 34°15'S and longitudes 22°45'-30°15'E). The plant was identified at the Department of Botany, University of Fort Hare and a voucher specimen (Vedic Med 2005/16) was prepared and deposited in the Griffen Herbarium of the University.

Scanning electron microscopy: Fresh leaf pieces (10 × 10 mm^2) from *S. aculeastrum* were immersed in a fixative solution of 2.5% glutaraldehyde in 0.1 M phosphate buffer for 24 h. Samples were washed for 15-30 min with the buffer and dehydrated in graded ethanol series. Samples were then critical-point dried using CO_2, sputter coated with gold under vacuum and viewed with Hitachi (S-450) scanning electron microscope operating at 10 kV. Images were captured digitally with an Image Slave computer programme for Windows.

RESULTS AND DISCUSSION

The investigation of the adaxial and abaxial surfaces of the leaves of *S. aculeastrum* showed numerous glandular and non-glandular trichomes (Fig. 1-3). This is a natural phenomenon in most angiosperms (Fahn, 1967). Representative scanning electron micrographs of leaf sections are shown in Fig. 1A-3D. Two types of glandular trichomes, short-stalked (SST), long-stalked (LST) and one type of non-glandular, stellate trichomes were identified on the leaves. However, SST were more abundant on the adaxial leaf surface (Fig. 1A-C). They consist of a basal epidermal cell and a 3-tiered stalk with a large round head (Fig. 1B and C). The LST were present

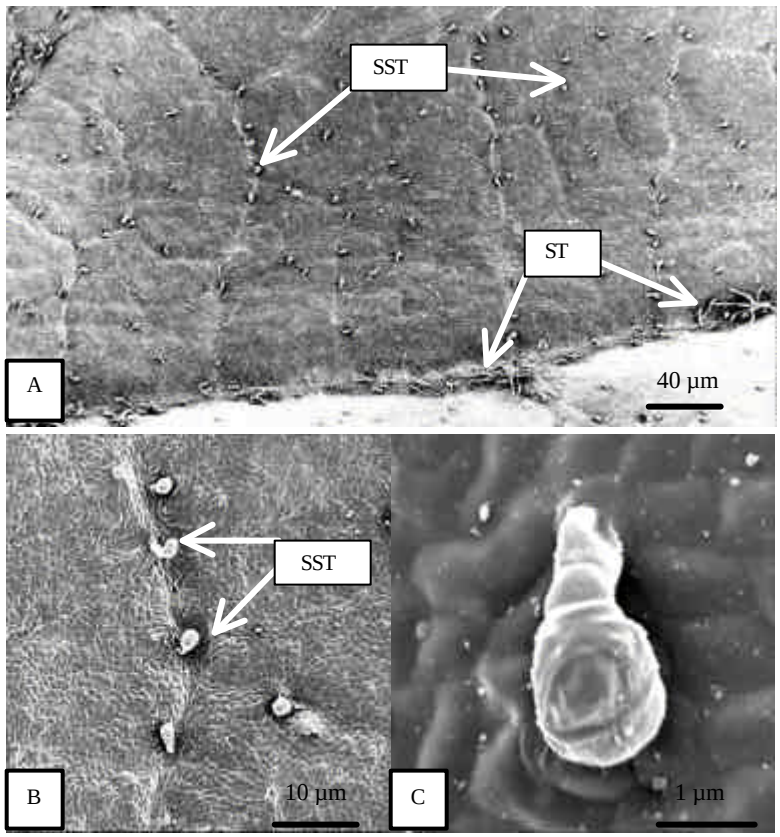

Fig. 1: SEM photographs. A: A portion of the adaxial surface of a leaflet of *S. aculeastrum* covered by glandular (SST) and non-glandular trichomes (ST). B: Glandular trichomes (SST) were distributed on the veins of the leaf. C: Glandular trichome consisting of stalk (St) bearing a secretory cell (Sc) at the tip. SST, Short-stalked trichome; SST, Non-glandular Trichome; ST, Stellate trichome; St, Stalk; Sc, Secretory cell. Scale bar in A = 40, in B = 10 and in C = 1 µm

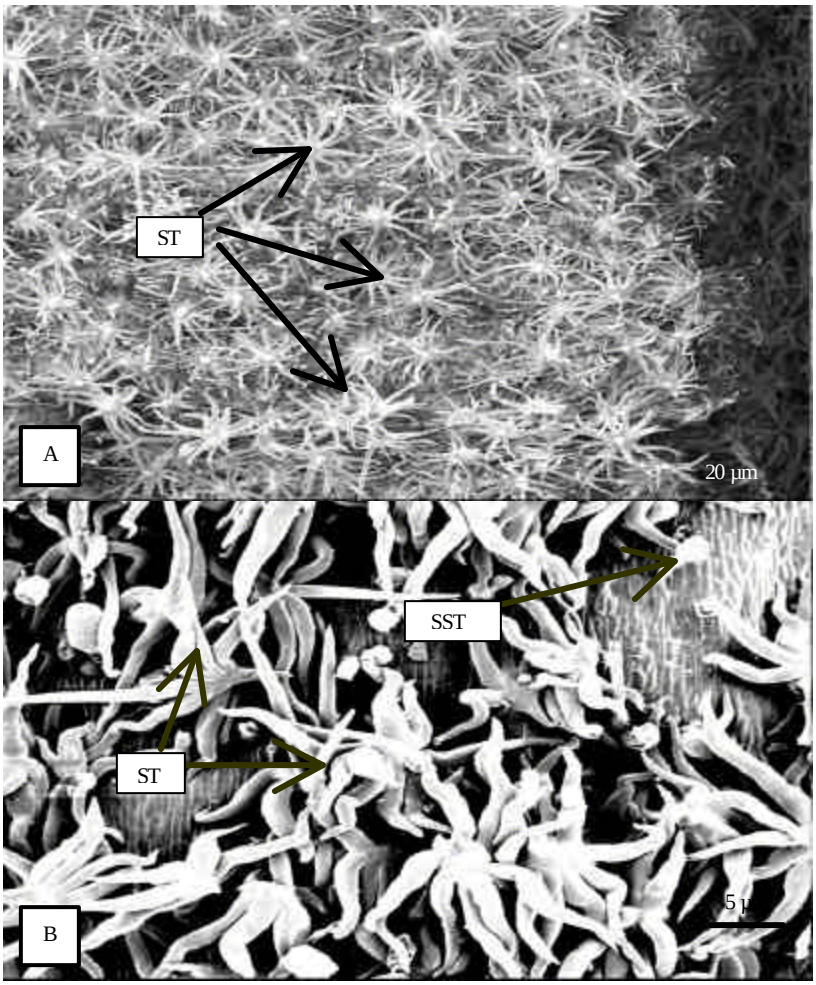

Fig. 2: SEM photographs of non-glandular trichomes on the abaxial surface of the leaf of *S. aculeastrum*. A. distribution of the Stellate Trichomes (ST). B. presence of Short-stalked Trichomes (SST) with ST. Bar in A = 20, in B = 5 µm

only on the abaxial surface of the leaf (Fig. 3A-D) along with the ST, the later were however, more abundant and densely distributed than on the upper surface of the leaves (Fig. 1A, 2A and B and 3A-D). Each ST appeared solitary but, multicellular and pointed with 13-15 arms (Fig. 2A-B).

Glandular trichomes are characterized by having 'heads' (glands) that release, on contact, sticky and/or toxic exudates that may entrap, irritate or potentially kill some pests (Simmons *et al*., 2003). These glands contain important secondary metabolites including terpenes, essential oils, flavonoids and lipophilic components (Levin, 1973; Dell and McComb, 1978; Wagner, 1991; Afolayan and Meyer, 1995; Ascensao *et al*., 1999). In most species, the source of these secondary metabolites has been attributed to the trichomes (Buta *et al*., 1993). The possession of glandular trichomes is characteristic of the genus *Solanum* and of many other members of Solanaceae, with the exception of *Nicotiana glauca* and *Solandra nitida* (Maiti *et al*., 2002). The two types of glandular trichomes identified on the leaves of *S. aculeastrum* might be responsible for the production, accumulation and release of volatile and secondary metabolites such as the saponins and steroid alkaloids reported by Drewes and Van Staden (1995). Although, micro-morphological studies alone do not provide the information required to establish sites of synthesis in cells (Afolayan and Meyer, 1995), it is plausible to assume that the therapeutic compounds in *S. aculeastrum* are produced by the glandular trichomes.

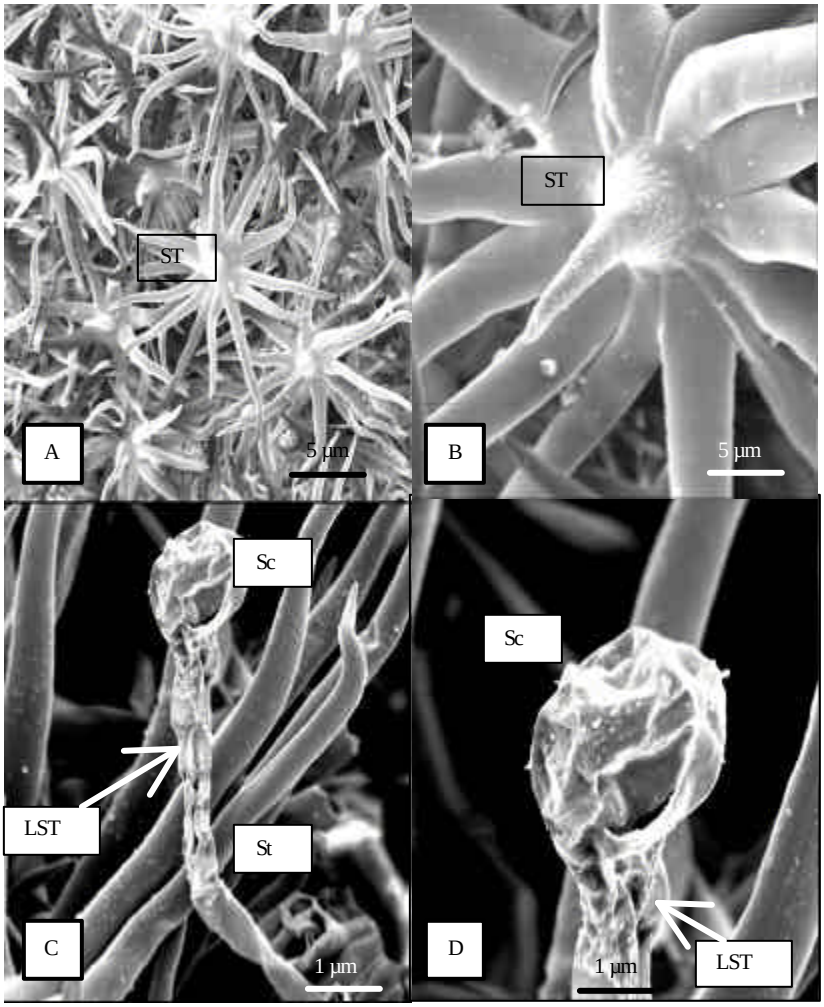

Fig. 3: SEM photographs of non-glandular trichomes on the abaxial surface of the leaf of *S. aculeastrum*. A and B. Stellate trichome distribution with arms (ST). C and D. Presence of Long-stalk Trichomes (LST) on the abaxial surface. Sc, Secretory cells. St, Stalk. Bar in A = 5, in B = 1, in C = 1 and in D = 1 µm

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